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Turner et al.

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(54) **SELECTIVE FRACTURING TOOL**

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USPC 166/373, 381, 383, 386, 318, 332.1, 166/332.4
See application file for complete search history.

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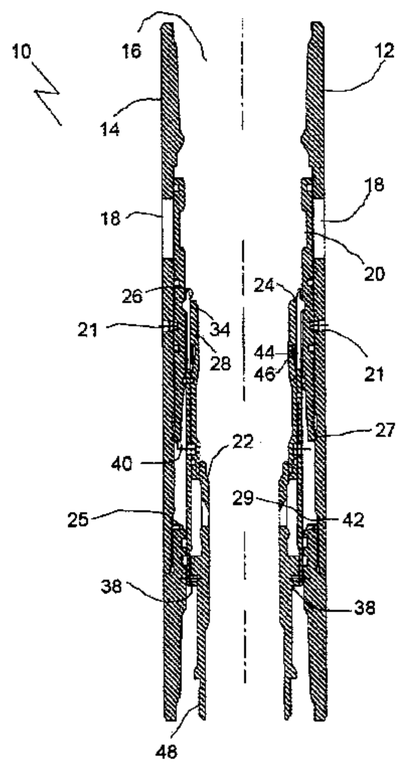
(57) **ABSTRACT**

A tool for selectively treating a wellbore with fluid that includes a tubing string having a sidewall defining an inner bore, the sidewall comprising a flow area having at least one fluid flow port that permits fluid flow through the sidewall. Fluid is prevented from flowing through the flow area when a closure is in a closed position. When in the open position, fluid flows through the flow area. An axial seal is connected to the closure to selectively close the inner bore against fluid pressure to apply the predetermined opening force to move the closure to the open position. A releasable connector connects the axial seal to the closure and a retrieval tool attachment releases the axial seal from the closure upon application of a predetermined release force by a retrieval tool.

22 Claims, 7 Drawing Sheets



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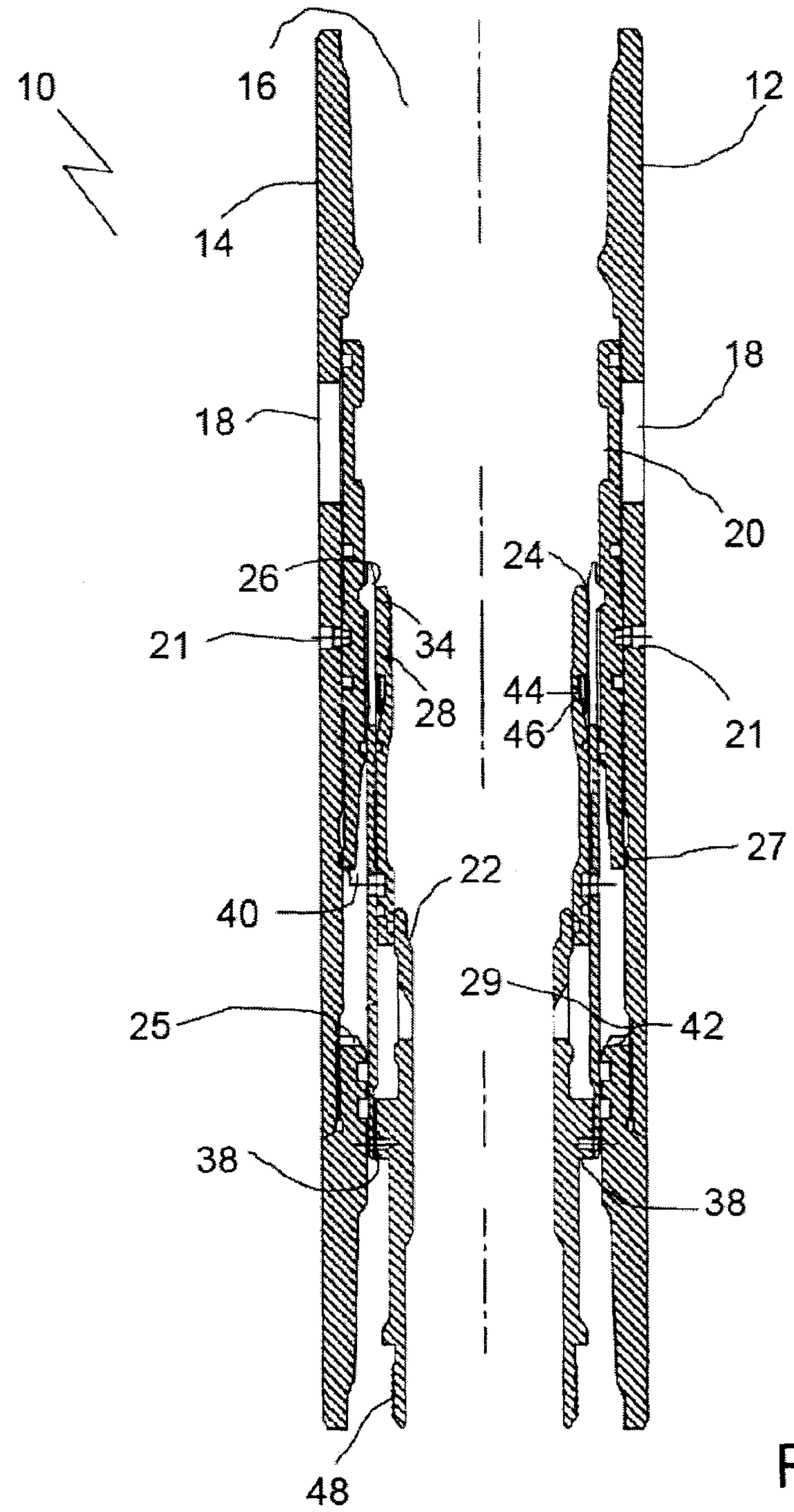
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FIG. 1

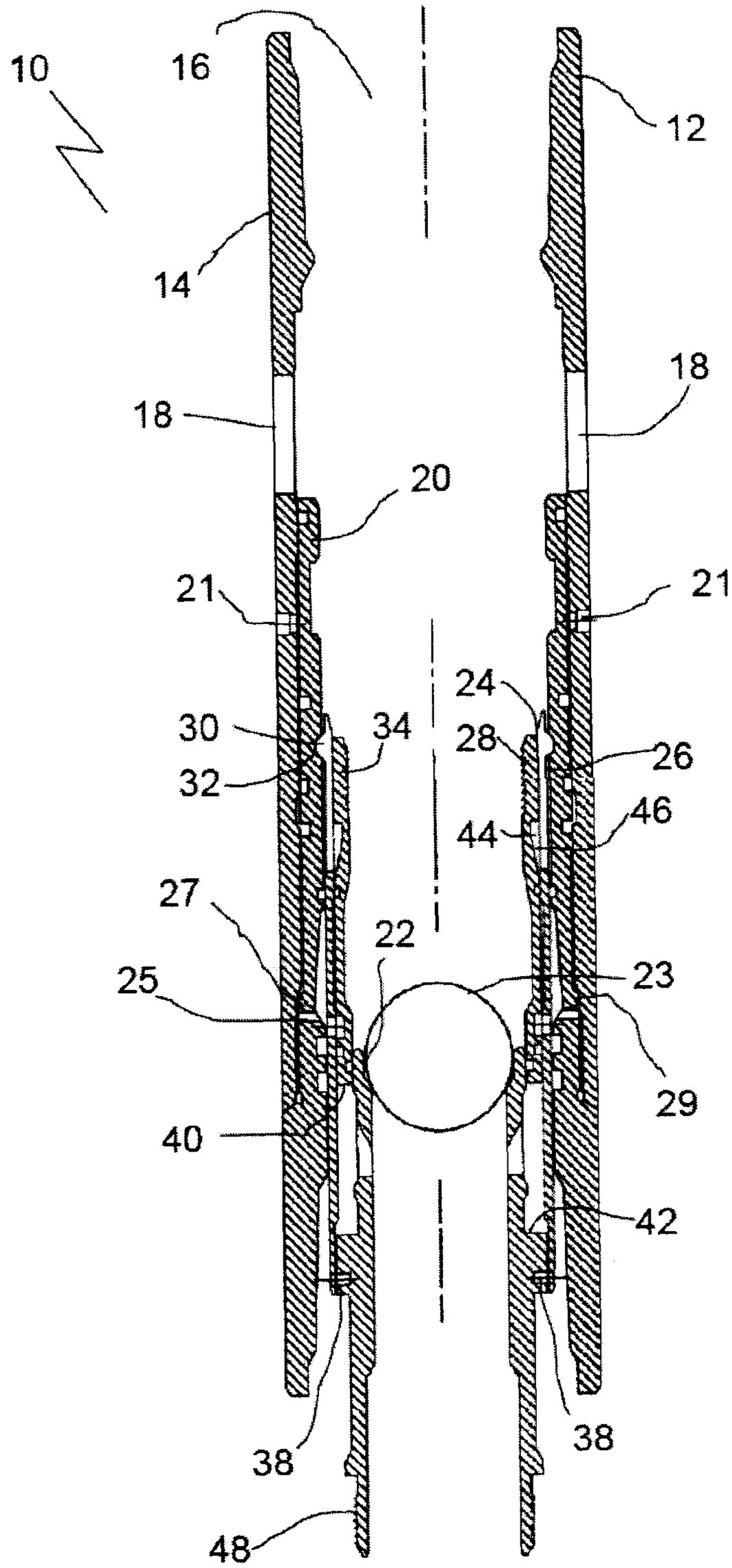
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FIG. 2

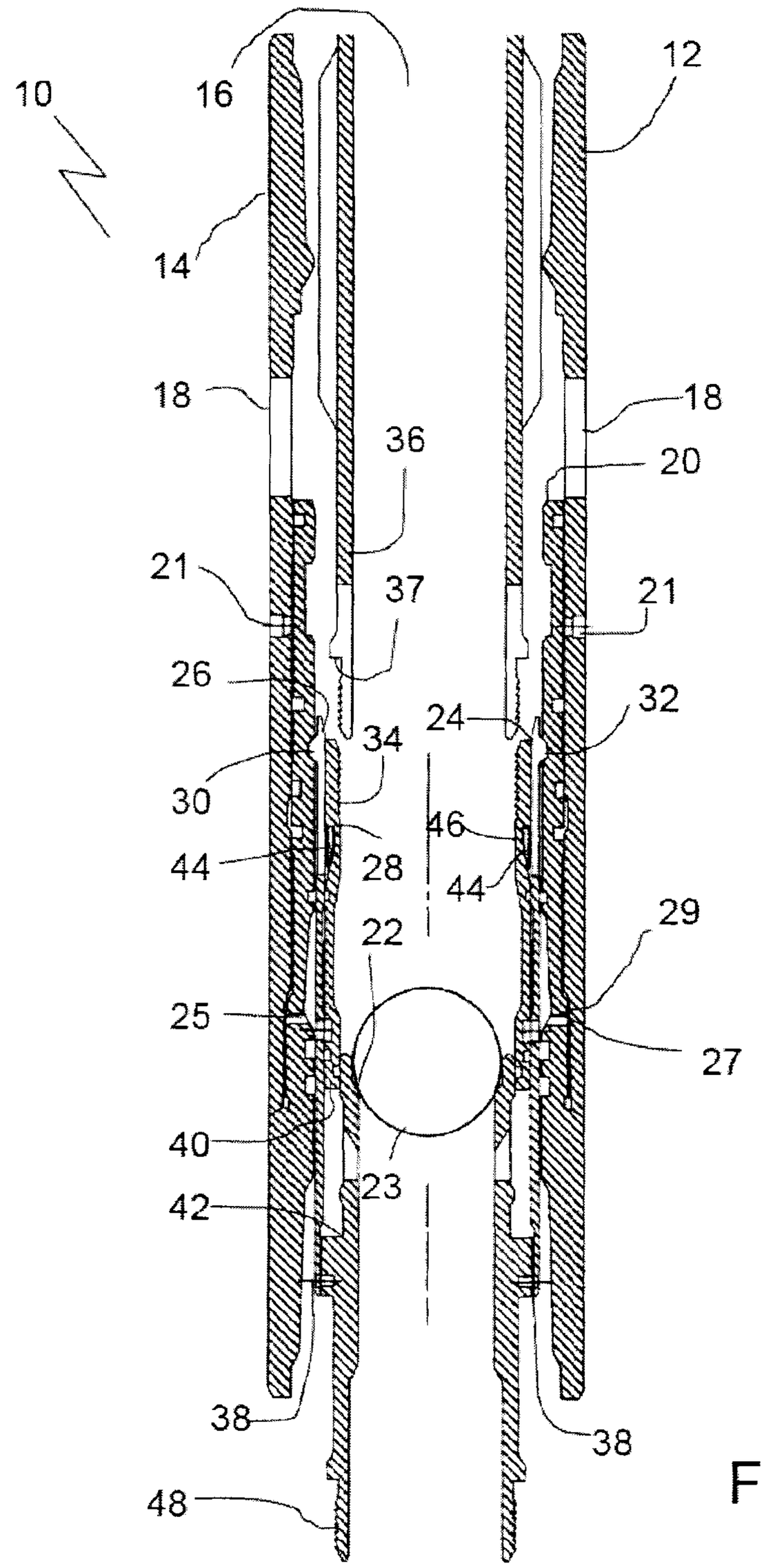
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FIG. 3

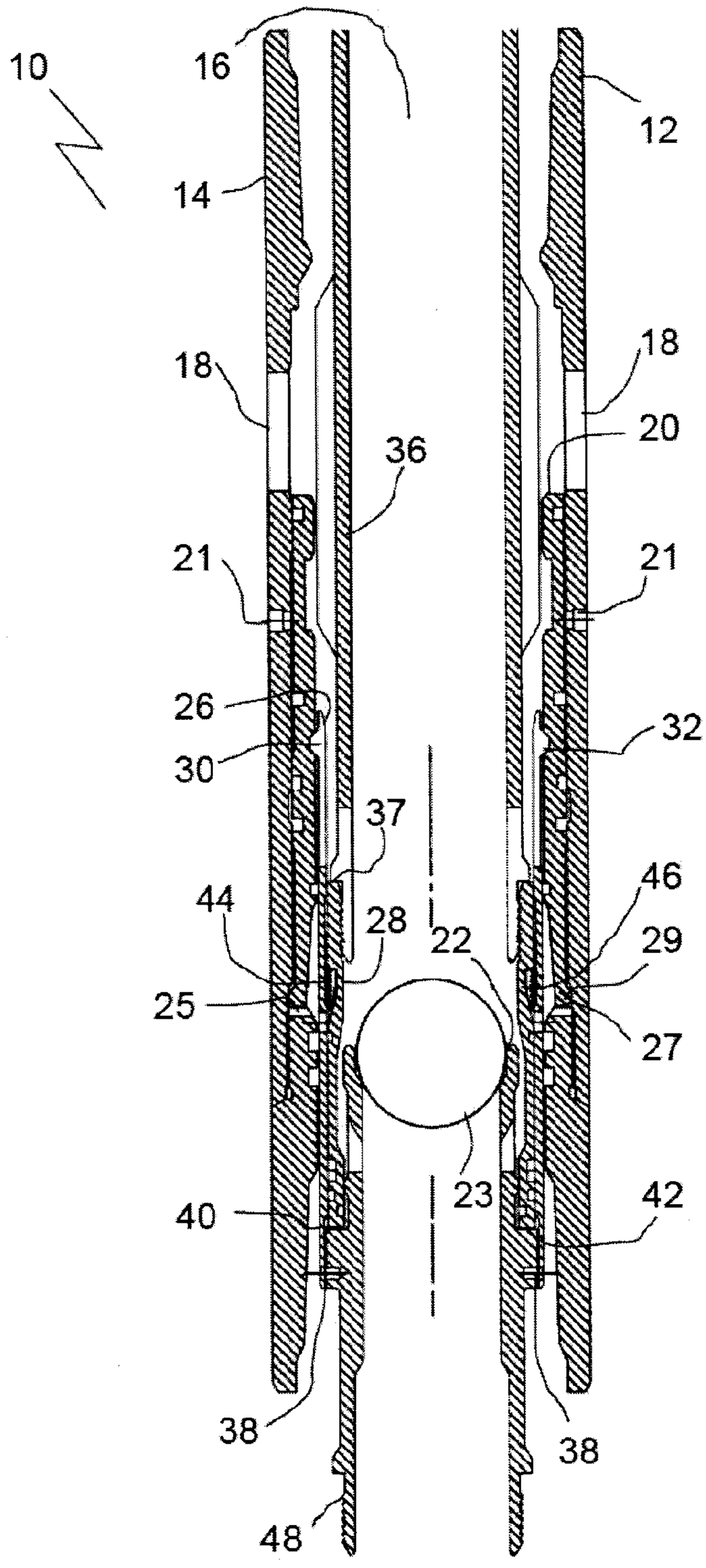
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FIG. 4

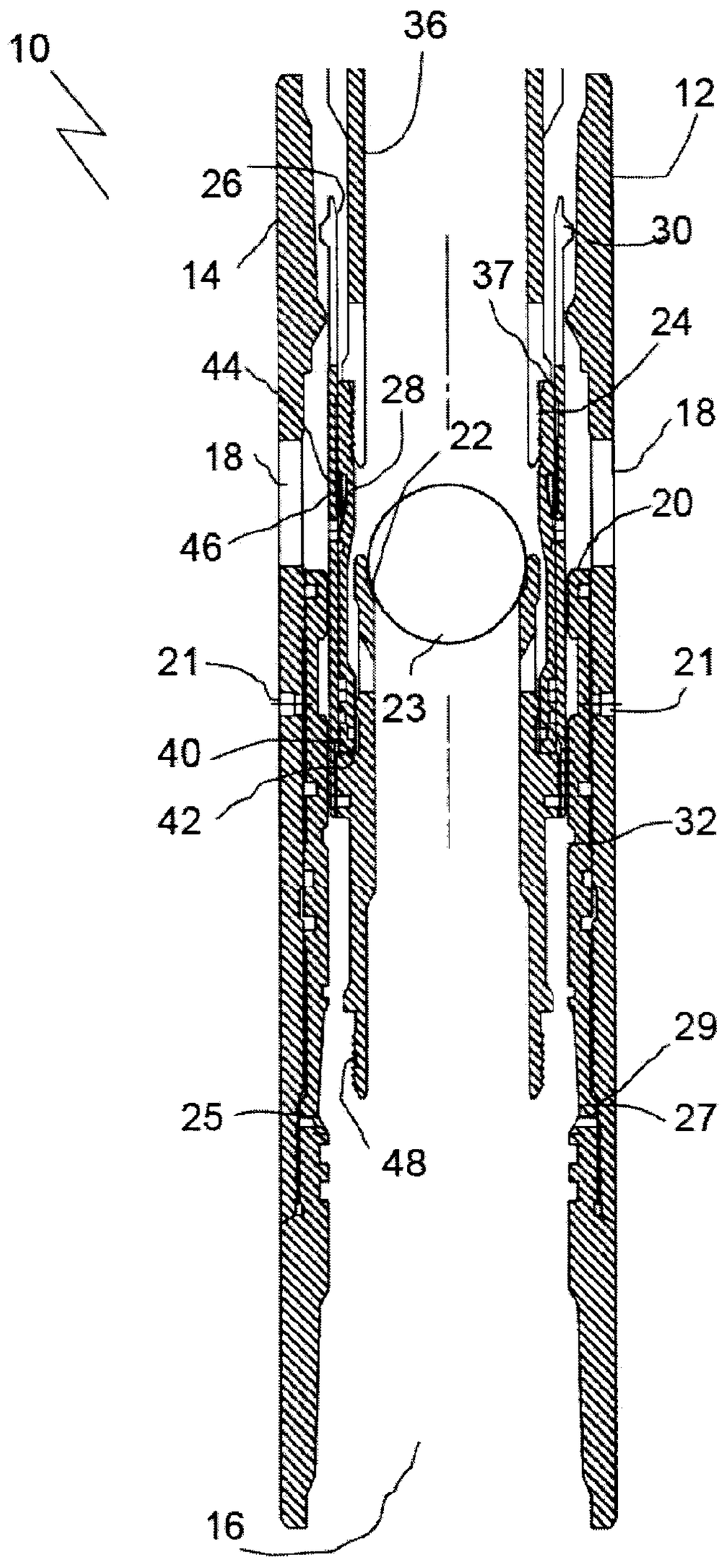
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FIG. 5

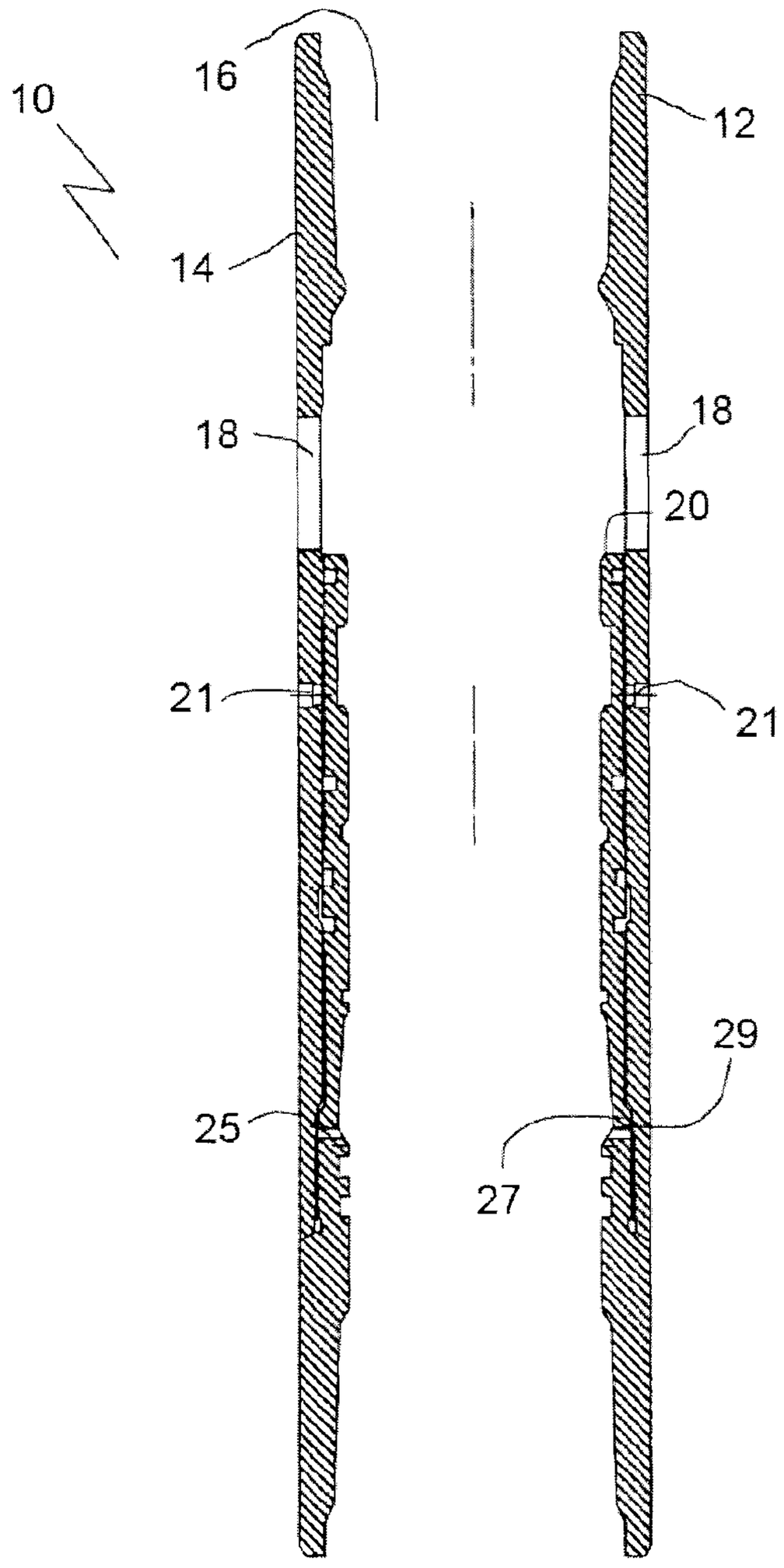

FIG. 6

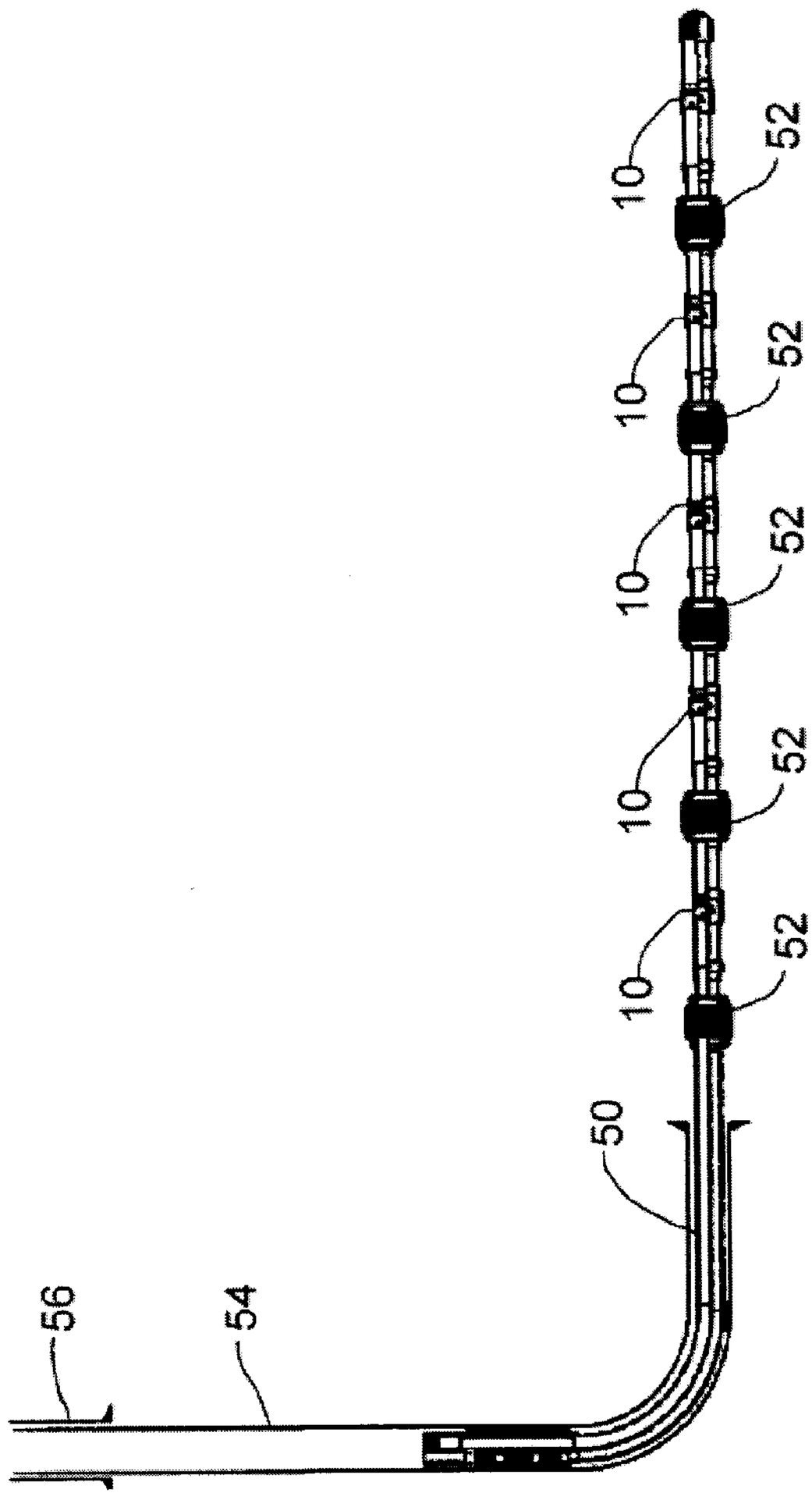

FIG. 7

SELECTIVE FRACTURING TOOL

FIELD

This relates to a tool for selectively fracturing a formation containing hydrocarbons.

BACKGROUND

U.S. Pat. No. 7,108,067 (Themig et al.) entitled "Method and apparatus for wellbore fluid treatment" describes a tool in which sleeves are shifted in order to open fracing ports.

SUMMARY

There is provided a tool for selectively treating a wellbore with fluid that includes a tubing string having a sidewall defining an inner bore, the sidewall comprising a flow area having at least one fluid flow port that permits fluid flow through the sidewall. A closure is movably positioned over the flow area and prevents fluid flow through the flow area in a closed position and allows fluid flow in an open position. An axial seal is connected to the closure to selectively close the inner bore against fluid pressure to apply the predetermined opening force to move the closure to the open position. A releasable connector connects the axial seal to the closure and a retrieval tool attachment releases the axial seal from the closure upon application of a predetermined release force by a retrieval tool.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features will become more apparent from the following description in which reference is made to the appended drawings, the drawings are for the purpose of illustration only and are not intended to be in any way limiting, wherein:

FIG. **1** is a side elevation view, in section, of the selective fracturing tool.

FIG. **2** is a side elevation view, in section, of the selective fracturing tool shown in FIG. **1** with flow ports in the open position.

FIG. **3** is a side elevation view, in section, of the selective fracturing tool shown in FIG. **1** with a removal tool inserted.

FIG. **4** is a side elevation view, in section, of the selective fracturing tool shown in FIG. **1** with the removal tool locked in position

FIG. **5** is a side elevation view, in section, of the selective fracturing tool shown in FIG. **1** with the removal tool removing the ball seat.

FIG. **6** is a side elevation view, in section, of the selective fracturing tool shown in FIG. **1** with full bore access.

FIG. **7** is a side elevation view of a tubing string containing a series of selective fracturing tools.

DETAILED DESCRIPTION

A selective fracturing tool, generally identified by reference numeral **10**, will now be described with reference to FIG. **1** through **7**.

Referring to FIG. **1**, tool **10** has a tubing string **12** having a sidewall **14**, an inner bore **16** and flow areas made up of one or more flow ports **18** that permit fluid flow through sidewall **14**. A closure **20** is positioned over flow ports **18**. As shown, closure **20** is an annular sleeve that shifts axially within sidewall **14**, and is connected to sidewall **14** by shear pins **21**. Closure **20** is initially in a closed position as shown in FIG. **1** to prevent fluid flow through flow ports **18**, and may be moved to an open position, shown in FIG. **2** and described below, to allow fluid to flow through flow ports **18**. As shown in FIG. **4**, tubing string **12** includes multiple flow areas **18** that are axially spaced, each having a closure **20** and the other components described below. An axial seal **22**, such as a ball seat as depicted, is connected to closure **20**. Axial seal **22** is initially in an open position, but may be closed to seal inner bore **16**, such as by placing a ball **23** in ball seat **22**, which allows pressure to be applied to closure **20** to move closure **20** to the open position. Axial seal **22** is attached to closure **20** via a releasable connector **24** that is released by a retrieval tool as discussed below. Referring to FIG. **2**, in the depicted embodiment, a ball **23** is pumped down tubing string **12** and engages ball seat **22**. Fluid pressure is then applied by increasing the hydrostatic pressure in inner bore **16**. This causes closure **20** to shear shear pins **21** and shift axially to open flow ports **18**. It will be understood that closure **20** may also open flow ports **18** by, for example, being rotated by the fluid pressure applied to ball seat **22**. In addition, other means of releasing closure **20** may also be used. In the open position, closure **20** is stopped by a shoulder **25** on sidewall **14**, and preferably has a latch end **27** that engages a latching profile **29** in sidewall **14** to prevent it from unintentionally returning to the closed position.

Preferably, when multiple closures **20** are selectively shifted, the diameter of downstream ball seats **22** are progressively smaller than the upstream ball seats **22**, such that a smaller ball may be pumped down through other, larger, ball seats **22** to the end of tubing string **12** to open that closure. The next ball will be larger to engage the next ball seat **22**, but still small enough to pass through the upstream ball seats **22**, and so forth so that all closures **20** are opened.

Referring to FIG. **3**, once opened, axial seal **22** can then be removed to provide "full bore" access to tubing string **12** by releasing releasable connector **24**. In the depicted embodiment, releasable connector **24** is made up of a diameter reducing sleeve **26** and a locking sleeve **28**. Sleeve **26** has an outer profile **30** that engages a corresponding profile **32** on closure **20**. As shown, profiles **30** and **32** are sloped on both sleeve **26** and closure **20**. This portion of sleeve **26** is a diameter reducing section. This may be done by providing a series of resilient fingers that, when an axial force is applied in either direction, bend inward to release sleeve **26** from closure **20**. Preferably, the fingers are biased inward, such that once they are released, they do not catch on closure **20**. The space between the resilient fingers may be filled with a compressible substance to properly seal sleeve **26**. Axial seal **22** is attached, such as by pins **27**, to the other end of diameter-reducing sleeve **26**. Sleeve **28** is a locking sleeve that prevents diameter reducing sleeve from being released from profile **32** on closure **20**. Locking sleeve **28** has a retrieval tool attachment **34** at one end that engages a retrieval tool **36**, and is connected by shear pins **38** to one of axial seal **22** or sleeve **26** at the other end.

Referring to FIG. **4**, as shown, retrieval tool **36** engages retrieval tool attachment **34** using a ratchet design that allows it to be inserted in one direction, and afterward locks in place. Retrieval tool **36** has a shoulder **37** to prevent it from being inserted too far into locking sleeve **28**. Shoulder **37** is then used to apply pushing forces to locking sleeve **28**. When retrieval tool **36** applies a sufficient force to release shear pins **38**, locking sleeve **28** shifts downward and diameter reducing section is no longer locked in place. Locking sleeve **28** then becomes locked into this release position, as the downstream end **40** of locking sleeve **28** comes into contact with a shoulder **42** of axial seal **22**, and dogs **44**, which are mounted in a

groove **46** locking sleeve **28** against a sloped outer surface, engage diameter reducing sleeve **26** by friction to prevent locking sleeve **28** from moving back to the locked position. This allows a pushing or pulling force to be applied by retrieval tool **36** at this point that will move axial seal **22** and sleeves **26** and **28** together to remove retrieval tool **36**.

Referring to FIG. **7**, a series of selective fracing tools **10** are deployed along a production tubing string **50** with packers **52**, such as hydraulically set dual element open hole packers. The type of packer used will be selected based on the conditions and preferences of the user. Tubing string **50** is inserted into the casing **54** of a wellbore **56**, such that tool **10** is aligned with the portion of the formation to be fraced.

When multiple fracing tools **10** are used as shown in FIG. **7**, each axial seal **22** may be removed individually to obtain the full bore flow path shown in FIG. **6**. In this approach, retrieval tool **36** is inserted once for each axial seal **22**. Alternatively, more than one axial seal **22** may be removed in multiples. As shown, in FIG. **4**, axial seal **22** has a downstream end **48** that has a similar connection as retrieval tool **36**. Once an upstream axial seal **22** is released, it may be pushed to engage the next downstream axial seal **22**, where downstream end **48** engages retrieval tool attachment **34** of the next axial seal **22**. At this point, axial seal **22** can be considered part of the retrieval tool **36**. The axial seals **22** can then be pulled out of tubular body **12** at the same time.

In this patent document, the word "comprising" is used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite article "a" does not exclude the possibility that more than one of the element is present, unless the context clearly requires that there be one and only one of the elements.

The following claims are to be understood to include what is specifically illustrated and described above, what is conceptually equivalent, and what can be obviously substituted. Those skilled in the art will appreciate that various adaptations and modifications of the described embodiments can be configured without departing from the scope of the claims. The illustrated embodiments have been set forth only as examples and should not be taken as limiting the invention. It is to be understood that, within the scope of the following claims, the invention may be practiced other than as specifically illustrated and described.

What is claimed is:

1. A tool for selectively treating a wellbore with fluid, comprising:

tubing having a sidewall defining an inner bore, the sidewall comprising a flow area having at least one fluid flow port that permits fluid flow through the sidewall;

a closure positioned over the flow area, the closure movable from a closed position that prevents fluid flow through the flow area to an open position that allows fluid flow through the flow area upon application of a predetermined opening force;

an axial seal connected to the closure, the axial seal selectively closing the inner bore against fluid pressure to apply the predetermined opening force to move the closure to the open position;

a releasable connector connecting the axial seal to the closure; and

wherein the tubing comprises multiple flow areas axially spaced along the sidewall, each flow area having an associated closure, axial seal, releasable connector, and retrieval tool attachment; and

wherein the releasable connector comprises:

a diameter reducible sleeve that engages the closure; and

a locking sleeve having a locking position over the diameter reducible sleeve and a release position axially shifted from the diameter reducible sleeve, the locking sleeve being shiftable to the release position upon application of the predetermined release force.

2. The tool of claim **1**, wherein the axial seal is a ball seat that receives a pumped ball.

3. The tool of claim **1**, wherein each axial seal is a ball seat, the diameter of the ball seats varying along the length of the tubing string.

4. The tool of claim **1**, wherein the axial seal is secured to the diameter reducible sleeve and the locking sleeve is releasably secured to one of the axial seat and the diameter reducible sleeve by shear pins.

5. The tool of claim **1**, wherein the locking sleeve is permitted to move relative to the diameter reducible portion in a first direction, and locks against the diameter reducible portion in an opposed, second direction.

6. The tool of claim **1**, wherein the axial seal and the releasable connector are removed from the tubing string upon application of a force applied by the retrieval tool after the axial seal has been released from the closure.

7. The tool of claim **1** further comprising a downstream end of the first axial seal for connecting to a second axial seal of a second closure downstream from the first axial seal.

8. The tool of claim **7**, wherein the second axial seal is connected with the second closure by a second releasable connector, wherein the downstream end of the first axial seal is configured for applying a force for releasing the second releasable connector once the first axial seal is released from the first closure and moved downstream for connection to the second axial seal.

9. The tool of claim **8**, further comprising a retrieval tool for lowering through the inner bore and applying a force for releasing the first axial seal from the first closure.

10. The tool of claim **7**, wherein the first and second axial seals are each comprised of a ball seat for receiving a pumped ball to close the inner bore.

11. The tool of claim **10**, wherein the ball seat for the first axial seal has a larger diameter than the ball seat of the second axial seal.

12. A method of selectively treating a wellbore with fluid, comprising the steps of:

providing:

tubing having a sidewall defining an inner bore, the sidewall comprising a first flow opening that permits fluid flow through the sidewall;

a first closure positioned over the first flow opening;

a first axial seal connected to the first closure in an open state; and

a first releasable connector connecting the first axial seal to the first closure;

closing the first axial seal and applying a predetermined opening force to move the first closure to an open position that permits fluid flow through the first flow opening;

inserting a retrieval tool into the tubing string and attaching the retrieval tool to the first axial seal; and

releasing the first axial seal from the first closure by applying with the retrieval tool a predetermined release force to the first releasable connector;

wherein the first releasable connector comprises:

a diameter reducible sleeve that engages the closure; and

a locking sleeve having a locking position over the diameter reducible sleeve and a release position axially shifted from the diameter reducible sleeve, the lock-

ing sleeve being shifted to the release position upon application of the predetermined release force.

13. The method of claim **12**, comprising, for at least one additional flow opening, repeating the steps of:

closing the axial seal and applying a predetermined opening force to move the closure to an open position that permits fluid flow through the flow opening;

inserting the retrieval tool into the tubing string and attaching the retrieval tool to the axial seal;

releasing the axial seal from the closure by applying a predetermined release force to the releasable connector.

14. The method of claim **12**, wherein the axial seal is a ball seat that receives a pumped ball.

15. The method of claim **12**, wherein each axial seat is a ball seat, the diameter of the ball seats varying along the length of the tubing string.

16. The method of claim **12**, wherein the axial seal is secured to the diameter reducible sleeve and the locking sleeve is releasably secured to one of the axial seat and the diameter reducible sleeve by shear pins.

17. The method of claim **12**, wherein the locking sleeve is permitted to move relative to the diameter reducible portion in a first direction, and locks against the diameter reducible portion in an opposed, second direction.

18. The method of claim **12**, wherein the axial seal and the releasable connector are removed from the tubing string upon application of a force applied by the retrieval tool after the axial seal has been released from the closure.

19. The method of claim **12**, further comprising removing the retrieval tool and the axial seal from the tubing string.

20. The method of claim **12**,

wherein the tubing string further comprises a second flow opening axially spaced downstream from the first flow opening, a second closure positioned over the second flow opening, and a second axial seal connected to the second closure by a second releasable connector; wherein a downstream end for at least the axial seal is configured for connecting to the second axial seal; and

wherein the method further comprises:

moving the first axial seal of the first flow port toward the second axial seal of the second flow port; and

releasing the second axial seal from the second closure of the second flow port with the downstream end of the first axial seal.

21. The method of claim **20**, wherein the first and second axial seals are pushed toward the end of the well bore.

22. The method of claim **20**, wherein the first and second axial seals are pulled together with the retrieval tool through the tubing toward the surface of the well.

* * * * *